[PS]Planning Lunar Surface Traverses for Robotic Scouting Followed by Crew*

Matthew C. Deans[1], Michael Broxton[1], Terry Fong[1], Mark Helper[2], Kip V. Hodges[3], Gerald G. Schaber[4], Harrison H. Schmitt[5], and Trey Smith[1]

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[1]Intelligent Robotics Group, NASA Ames, Moffett Field, CA (matthew.deans@nasa.gov)
[2]Geological Sciences, University of Texas, Austin, TX
[3]School of Earth and Space Exploration, Arizona State University, Tempe, AZ
[4]Astrogeology, USGS (Ret.), Flagstaff, AZ
[5]University of Wisconsin, Madison, WI

Abstract

NASA currently plans to return humans to the Moon with a campaign of regularly spaced surface missions. During the first few years, humans will be on the surface less than 10% of the time. During the 90% of time between crew visits, however, robots will be available for surface operations under ground control. This provides ample time for robotic reconnaissance, i.e., using a planetary rover to scout planned sorties prior to human activity. Scouting is well understood to be an essential phase of field work, particularly for geology, and can be: (1) traverse-based (examining stations along a route); (2) site-based (examining stations within a bounded area); or (3) survey-based (systematically collecting data along defined transects).

During recon, robot-mounted instruments can be used to examine the surface and subsurface at resolutions (e.g., um to cm scale) and at viewpoints not achievable from orbit. The data can then be used to prioritize targets of interest to improve the productivity of crew traverses. In addition, robotic recon can help identify and assess terrain hazards, as well as evaluate alternate routes. This helps reduce operational risk.

On November 6, 2008, we conducted a short lunar traverse planning exercise at the NASA Ames Research Center. The objective was to establish an initial traverse plan for part of a new manned mission to the Apollo 15 region and then to identify where ground-level

data (e.g., collected by robotic recon) would help refine the plan. The planning for this “Apollo 15B” mission focused on the area of Hadley Rille near Hadley C, and the ejecta blanket from Hadley C that is deposited on to Hadley Rille.

This paper presents the approach used to plan traverses. During the exercise, we used a variety of lunar datasets including recent high-res digital scans of Apollo Metric Camera (AMC) images, digital elevation models created from the AMC images, and other datasets (geologic map, Clementine UV-VIS data, etc.). All datasets were registered to the ULCN2005 and viewed in a customized version of Google Earth.

Two traverses are presented. The first is for a robotic scout, including rationale for the routes and sites chosen, observation and documentation tasks, and how observations augment remote sensing and inform EVA traverse plans. The second traverse is for crew. We again present science rationale for routes and sites; observation, documentation, and sampling tasks; and expected lunar science results.

Planning Lunar Surface Traverses for Robotic Scouting Followed by Crew

M. Deans[1], M. Broxton[1], T. Fong[1], M .Helper[2], K. Hodges[3], G. Schaber[4], H. Schmitt[5], & T. Smith[1]

[1]NASA Ames Research Center. [2]UT Austin. [3]Arizona State Univ. [4]USGS (retired). [5]IHMC.

OBJECTIVES

- **Lunar planning exercise**: Develop crew traverse and identify where surface data would resolve uncertainti**es**
- **"Apollo 15B":** Revisit the Apollo 15 site (Hadley Rille and Montes Apenninus)
- **Geospatial browser**: Use Google Earth as low-cost, low barrier to entry, traverse planning tool

MISSION SUMMARY

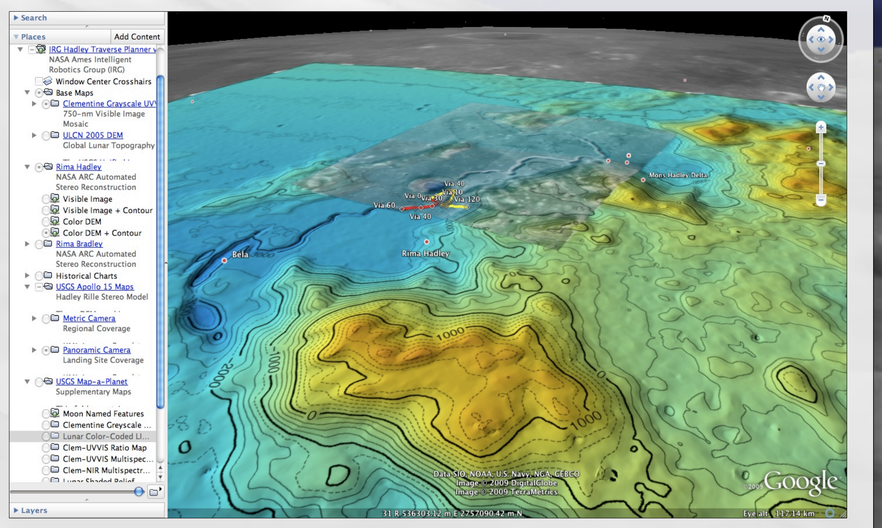
- **Landing Site**: 25.3N, 2.9E (provides direct access to Hadley C. and Hadley Rille)
- **Hadley C**: ejecta blanket provides deep crater sampling and bridge to Montes Appeninus
- **Montes Appeninus**: basin rim material might have originated deep within the Moon

ROBOTIC RECON

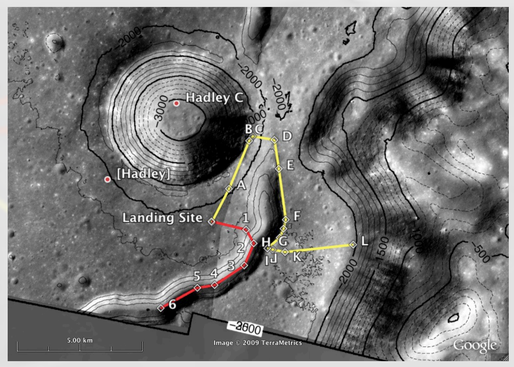
- **Return to the Moon**: Early on, humans only on the surface 10% of the time. Robots can do useful work the other 90%.
- **Remote sensing**: Insufficient to fully optimize planning (limited resolution, restricted view angle, lighting, etc.)
- **Scouting**: Mobile robot can collect (sub)surface data to improve science merit and reduce operational risk.

LUNAR DATASETS

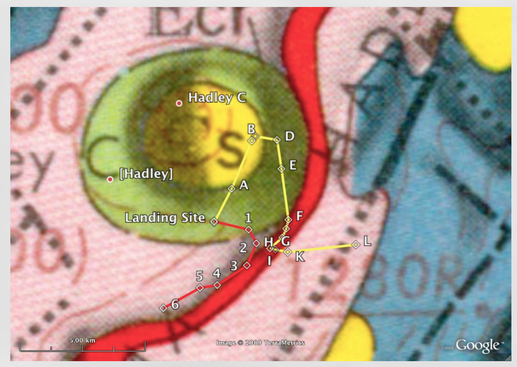
- **Apollo 15 Metric Cam (image & ARC DEM)**
- **Apollo 15 Panoramic (image & USGS DEM)**
- **Clementine (UVVIS, NIR, image basemap)**
- **Geologic Atlas**
- **Lunar Chart (LAC)**
- **ULCN 2005**



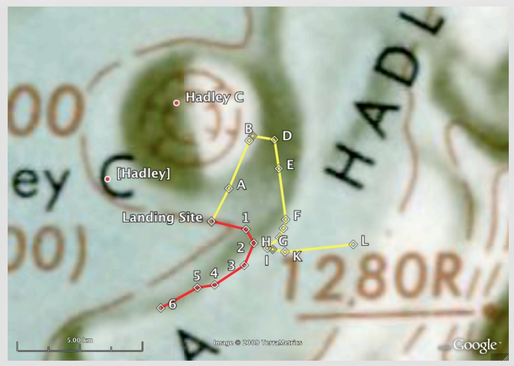
Apollo Panoramic Camera (2 m/pixel)



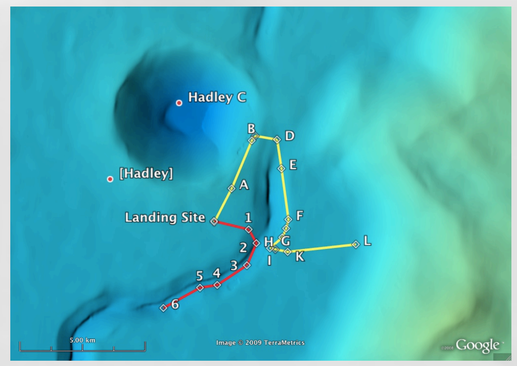
Geologic Atlas Montes Apenninus



Lunar Chart (LAC) Montes Apenninus

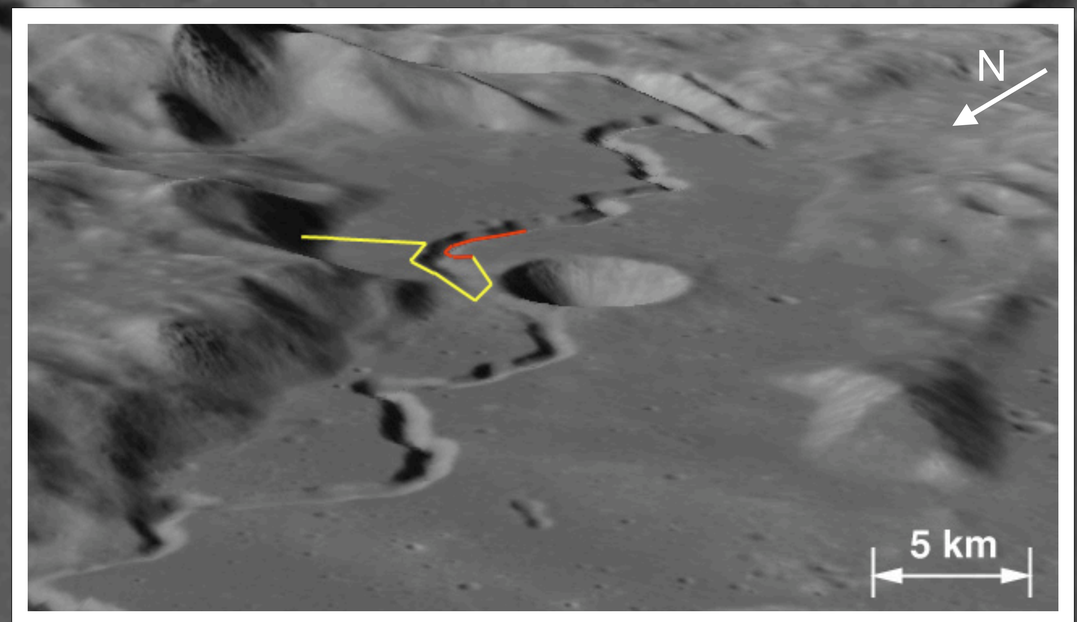


DEM (40 m/post from Apollo Metric Camera)



CREW TRAVERSE

- **Assumptions**: Apollo style (10 km walkback, on-foot or unpressurized crew rover)
- **Science objectives**: descend from landing site into Hadley Rille, traverse and sample the wall and bottom of Hadley Rille
- **Traverse Plan**: 7 km (one-way) with 6 stations



ROBOTIC RECON TRAVERSE

- **Assumptions**: Planetary rover with instruments (3D lidar, color pancam, multi-spectral imager, micro imager, GPR)
- **Objectives**: Scout Hadley C for possible EVA, assess backup descent route for crew, acquire remote view of crew traverse (from opposite side of Hadley Rille)
- **Traverse Plan**: 13 km (one-way) with 12 stations, crosses Hadley Rille and approaches Apennine Front